§23. Preliminary Results of Ideal MHD Stability Analysis for CHS-qa

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In this fiscal year, we have started ideal MHD stability analysis for CHS-qa, a quasi-axisymmetric stellarator designed as a candidate for the next satellite machine at NIFS. Due to complicated three dimensional (3D) magnetic field structure, 3D numerical calculation of ideal MHD stability is indispensable for the physics design of stellarators. Recently various 3D MHD codes such as Terpsichore, CAS3D, and Cobra have been developed for this purpose. In this study we have employed Terpsichore[1)] code for low mode number MHD modes such as external kink and vertical modes, and Cobra[2)] code for local ballooning mode.

Global MHD instability in helical configurations differs from that in tokamaks. Namely, for equilibrium configurations of which field period is N_p, Fourier mode with toroidal number n is coupled to other mode numbers $n+kN_p$, where k is an arbitrary integer. As for CHS-qa (N_p=2), toroidal mode numbers n=0, ±2, ±4, ... are coupled together, which makes N=0 mode family. The other N=1 family consists of mode numbers n=±1, ±3, ±5, ... in the same way. The former is periodicity preserving mode which contains so-called "vertical" modes familiar in tokamak theory, while the latter corresponds to "external kink" modes. Since radial distributions of pressure and current are intrinsically dependent each other, their self-consistent distributions should be used for detailed analysis. In this study, however, we have assumed reasonable distributions independently for simplicity. Effects of self-consistent bootstrap current and its profile on MHD stability should be examined in the future.

Figure 1 shows an example of the Terpsichore calculation for the current standard CHS-qa configuration called "2b32" with an aspect ratio of 3.2. Variation of eigenvalue with net toroidal current is shown in Fig. 1 for an average beta of 4%. Positive eigenvalue corresponds to stability. As for the current magnitude below 200 kA, N=0 family is kept stable, while N=1 family is slightly unstable for I_p=100–150 kA. It is interesting that N=1 family becomes stable again at I_p=200 kA. Once the total current exceeds 250 kA, both mode families become significantly unstable since external kink mode due to 1/2 rational surface appears.

Local ballooning stability was calculated by Cobra code. Figure 2 represents change in radial distribution of ballooning eigenvalue with increasing the average beta. In contrast to Fig. 1, negative eigenvalue corresponds to ballooning stability. Net plasma current was fixed at 50 kA. As shown, the beta limit for the ballooning mode is lower than that for global modes since instability occurs near the edge even for 2% average beta, and unstable area is spread with increasing beta. Since bootstrap current indirectly affects local ballooning stability via change in rotational transform, configurations stable for self-consistent bootstrap current should be investigated.

References

1) Anderson, D. V et al.: Int. J. Supercompt. Appl. **4** (1990) 34.

2) Sanchez, R. et al.: J. Comput. Phys. **161** (2000) 576.

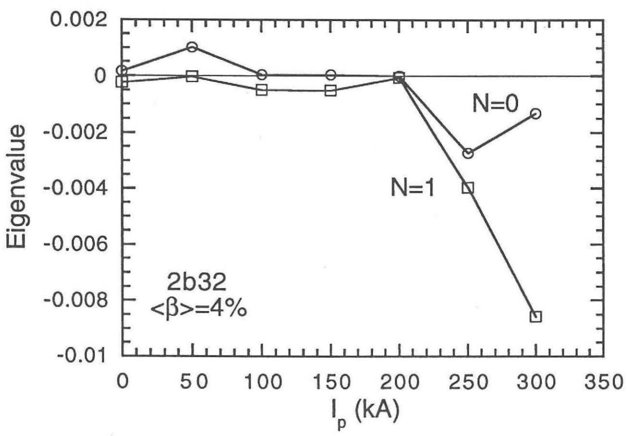

Fig. 1. N=0 and N=1 eigenvalues for the most unstable MHD modes in a representative CHS-qa configuration (2b32) as a function of net plasma current. The average beta value is fixed at 4%.

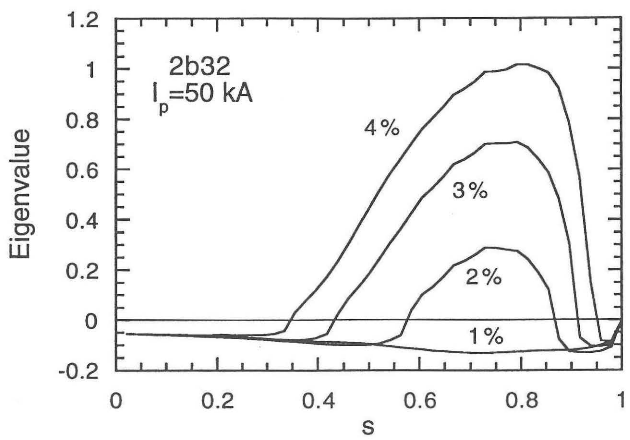

Fig. 2. Radial dependence of local ballooning eigenvalue for a CHS-qa configuration (2b32). Net plasma current is fixed at 50 kA.